

Report for 2001WI102B: A Basin-Scale Denitrification Budget for a Nitrate Contaminated Wisconsin Aquifer:

There are no reported publications resulting from this project.

Report Follows:

PROJECT SUMMARY

Title: A Basin-Scale Denitrification Budget for a Nitrate Contaminated Wisconsin Aquifer: A Study at the Groundwater/Surface Water Interface

Project ID: R/UW-GSI-002

Investigators:

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Period of Contract: July 1, 2000 to June 30, 2002

Background/Need:

Nitrate is a pervasive and increasing groundwater contaminant in Wisconsin. Many studies have found that nitrate is relatively conservative in groundwater. However, others have shown that nitrate can be transformed to nitrogen gas (denitrified) when reducing conditions are encountered along a groundwater flowpath (e.g., within riparian soil). Inadequate knowledge of groundwater denitrification hinders the development and application of accurate mass balance models for management of nitrate pollution.

Objectives:

The goal of this study was to achieve a better understanding of groundwater denitrification as a basin-scale control of nitrate concentrations and export from Wisconsin basins.

Methods:

The quantity and quality of groundwater discharging to the Little Plover River in Central Wisconsin was measured using a network of miniature wells at the groundwater/surface water interface (0.6 m beneath the streambed, distributed at 60-meter intervals over 10 km of headwater stream channel). Sampling surveys of all sites (n=160) were conducted in the summers of 2000 and 2001. A subset of sites (n=30) comprising a downwelling/upwelling sequence was sampled periodically. The concentration and load of denitrified-N carried into each 60-m stream segment via groundwater were quantified from the concentration of dissolved nitrogen gas (N₂) in excess of atmospheric equilibrium. Total groundwater nitrate was estimated from the sum of dissolved nitrate-N and excess N₂-N gas.

Results and Discussion:

For the average stream segment, 35% of groundwater nitrate-N (nitrate-N + denitrified-N) was discharged to surface water as excess N₂ gas (denitrified N). Higher denitrified N percentages were associated with one or more potential indicators (e.g., low dissolved oxygen, high dissolved organic carbon, low discharge per unit stream width) of shallow (e.g., riparian soil) groundwater flowpaths. Lower denitrified N percentages were

associated with indicators of deeper groundwater flowpaths (low DOC, high discharge per unit stream width). Summed across all stream segments, the cumulative loads of denitrified N and nitrate-N were 45 kg/day and 145 kg/day, respectively, representing a basin-wide denitrification rate of 24 percent. Extrapolated to an annual basis and expressed in terms of basin yield, these data indicate that approximately 54 kg/ha/yr were leached to groundwater as nitrate-N, of which 41 kg/ha/yr were released to surface water as nitrate-N. The remaining 13 kg/ha/yr were released to surface water as excess N₂-N (10 kg/ha/yr) or were transformed to excess N₂-N as surface water recharged groundwater in downwelling stream segments (3 kg/ha/yr).

Conclusions/Implications/Recommendations:

Though point estimates of denitrification have been routinely measured in soils and groundwater, estimates of denitrification on the scale of a small basin have been lacking. This study provides a basin-scale estimate of groundwater denitrification in a moderately thick (50-200 ft) surficial aquifer typical of many glacial/alluvial aquifers in Wisconsin. Because the annual recharge of the LPR aquifer is mostly derived during the rapid infiltration of coarse texture upland soils (which dominate the landscape), groundwater carries less DOC to fuel the respiratory consumption of O₂ and NO₃⁻ by microorganism than might be typical of other basins. Thus, our finding for the Little Plover River Basin could represent a lower bound basin-scale denitrification rate. Similar studies should be performed in other basins to determine how basin characteristics (e.g., soils, geomorphology) affect groundwater denitrification and further work should be done to clarify in what flow environments most denitrified N is generated (e.g., soil solution, capillary fringe/shallow water table, intermediate and regional flowpaths, or riparian/hyporheic zones).

Our results show that groundwater denitrification can substantially affect the total load and yields nitrate-N delivered to streams, and indicate that groundwater denitrification is an important factor controlling the collective release of N to large rivers systems from small agricultural basins.

Related Publications: none yet submitted

Key Words: nitrate, denitrification, groundwater/surface water interface, nitrous oxide, excess nitrogen gas.

Funding: UWS and USGS